Yacovone, Krista

From: DiPippo, Gary <Gary.DiPippo@Cornerstoneeg.com>
Sent: Thursday, September 03, 2015 2:34 PM
To: Gorin, Jonathan
Cc: Carrie McGowan
Subject: Mercury Solidification
Attachments: EPA_presentation(July 2011)(071211).pptx

Jon,

Carrie called me regarding your question about a site that did solidification and it didn't work very well. As Carrie and I were talking we wondered if you may be referring to the presentation we did that included the solidification done at the Bridge Street site on the fines after washing. So, attached is that presentation. Slide 36 summarizes some data (i.e., TCLP failure rate went up after solidification).

Maybe this will help.

If not, not sure which site you may be referring to.

Regards, Gary

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FOR DISCUSSION PURPOSES

Agenda

- Status of RI Comments and Open Issues
- Site Background Information
- Summary of Site Contamination
- Remedial Alternatives
- Alternatives Screening
- Key Considerations for Alternatives Evaluation
- Alternatives for Detailed Analysis

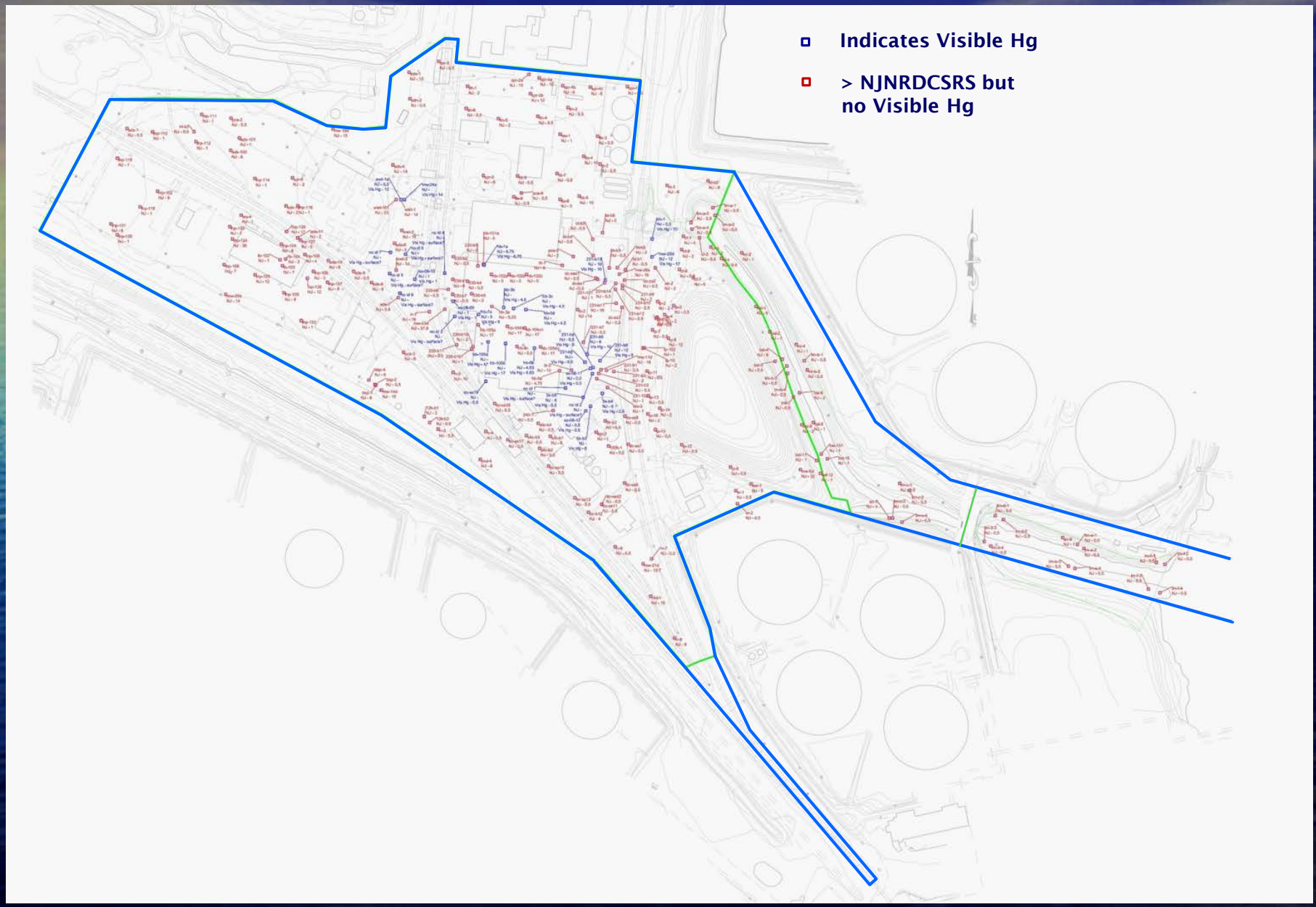
FOR DISCUSSION PURPOSES

Site Background Information

- 26 Acres
- Chlor-alkali production 1955-1985
- Filled predominantly prior to 1955
- Primary Contaminants
  - Hg site related and primary contaminant
  - HCB, PCN, PCDF, PCBs (also site related)
  - Metals, PAHs (fill related)
  - As, CB (adjacent properties)
  - Co-located with Hg
- Free, elemental Hg present
- Hg low mobility, low solubility
- Soil, groundwater, and sediment contamination
- Deep groundwater Hg contamination from adjacent Linden site - contained

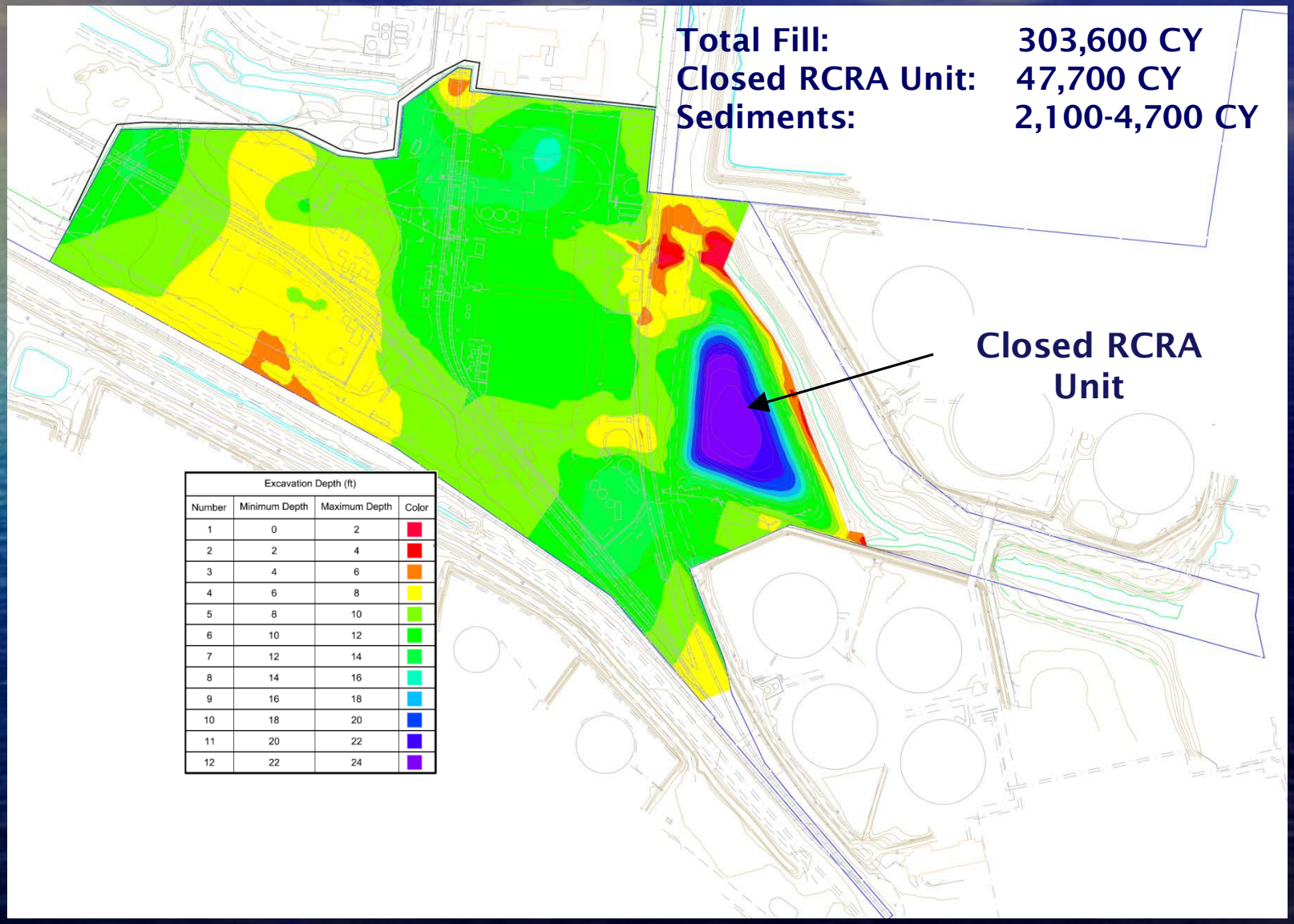
FOR DISCUSSION PURPOSES

Soils > NJNRDCSRS



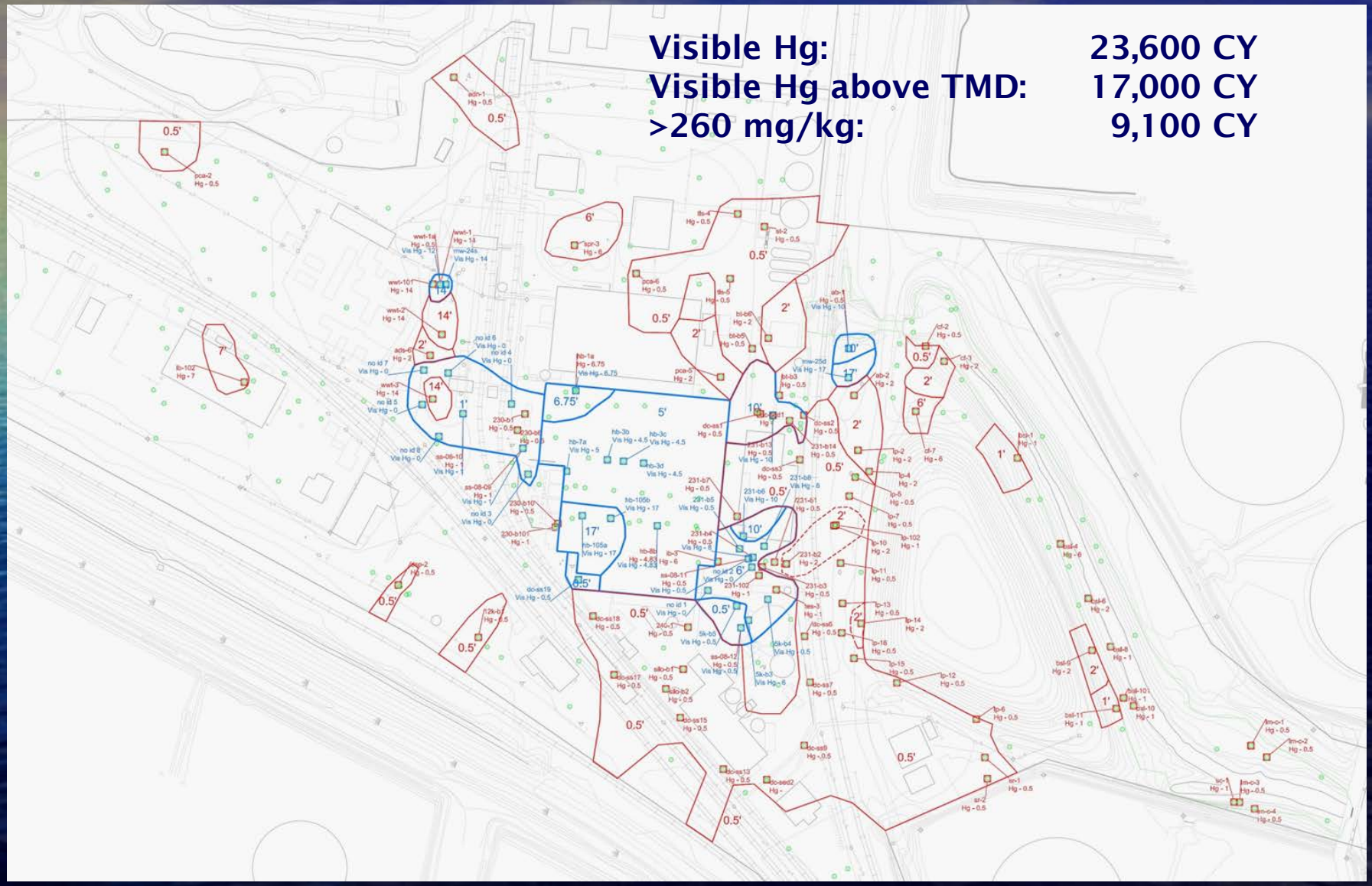
FOR DISCUSSION PURPOSES

Soil Quantities to Top of TMD



FOR DISCUSSION PURPOSES

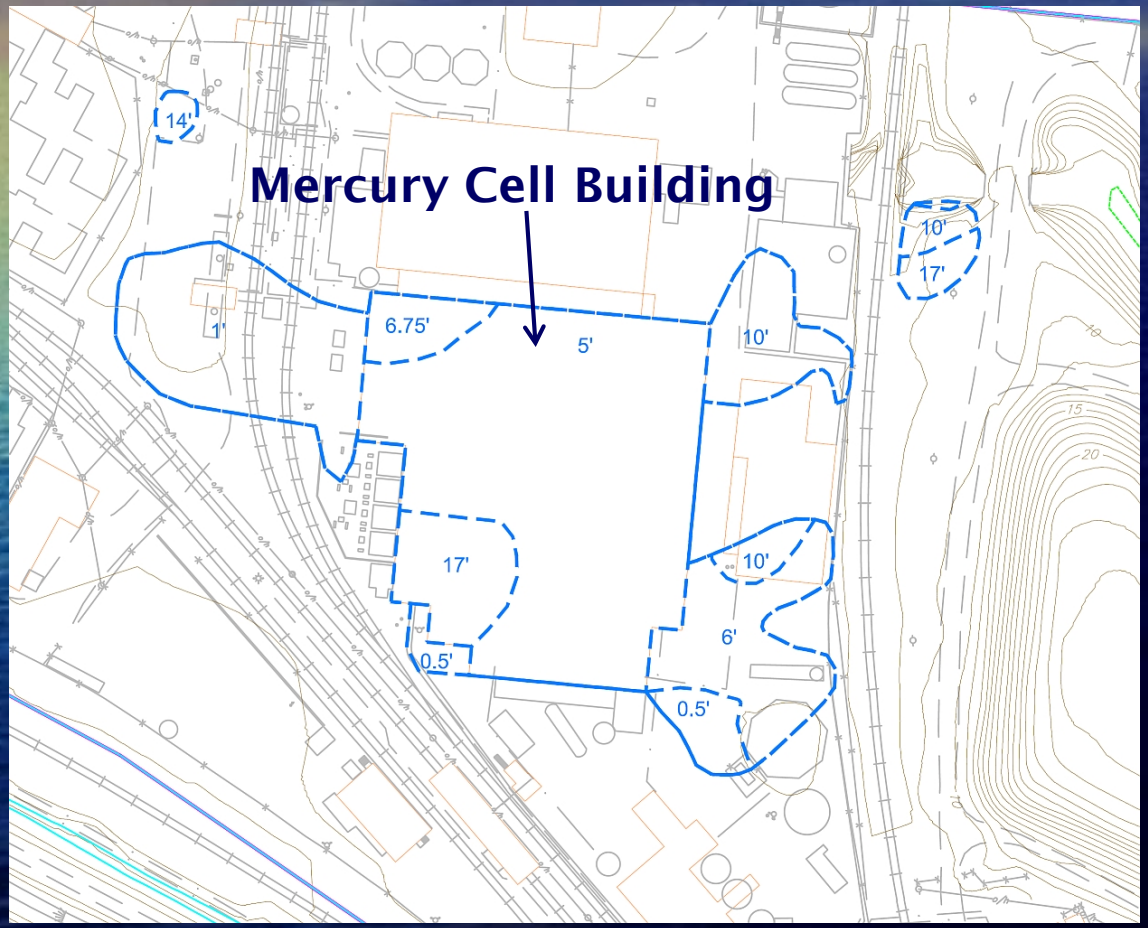
Selective Soil Quantities



Visible Hg:	23,600 CY
Visible Hg above TMD:	17,000 CY
>260 mg/kg:	9,100 CY

FOR DISCUSSION PURPOSES

Visible Mercury Distribution



Depth Interval (FT)	Visible Hg Volume (CY)	Cumulative Soil Volume
0 – 1	3,600	16%
1 – 3	5,800	40%
3 – 6	8,700	77%
6 – 10	3,300	91%
10 – 17	2,200	100%
Total	23,600	

Note: Avg. Depth to MTM 10'

Free Elemental Hg Mass

- Based on average concentration
  - In area of visible Hg
    - 25% Hg total is Hg^0
    - 0.7 lbs/CY
- LCP Bridge Street – 2.2. lbs/CY
- No distribution adjustment

FOR DISCUSSION PURPOSES

Soils Alternatives

- **Alternative 1S** - No Action
- **Alternative 2S** - Capping and Institutional Controls (IC)
- **Alternative 3S** – Selective Mercury Removal (vacuuming), Capping, Barrier Wall, and IC
- **Alternative 4S-1** - Partial Depth Selective Excavation and Disposal, Capping, and IC
- **Alternative 4S-2** – Full Depth Selective Excavation and Disposal, Capping, and IC
- **Alternative 5S** – Capping, Barrier Wall, and IC
- **Alternative 6S** – Treatment Cap, Barrier Wall, and IC

FOR DISCUSSION PURPOSES

Soils Alternatives

- Alternative 7S - Selective Treatment by Solidification/Stabilization, Capping, and IC
- Alternative 8S-1 - Selective Partial Depth Treatment by Stabilization, Capping, and IC
- Alternative 8S-2 – Selective Full Depth Treatment by Stabilization, Capping, and IC
- Alternative 9S-1 – Selective Partial Depth Treatment by Soil Washing, Capping, and IC
- Alternative 9S-2 – Selective Full Depth Treatment by Soil Washing, Capping, and IC
- Alternative 10S – Excavation and Off-Site Disposal

FOR DISCUSSION PURPOSES

Groundwater Alternatives

- **Alternative 1GW** - No Action
- **Alternative 2GW** - Capping and Barrier Wall, Shallow Groundwater Collection and Treatment, Long-Term Monitoring of Deep Groundwater, and IC
- **Alternative 3GW** - Shallow Groundwater Collection and Treatment, Long-Term Monitoring of Deep Groundwater, and IC
- **Alternative 4GW** - Monitored Natural Attenuation

FOR DISCUSSION PURPOSES

Sediments Alternatives

- **Alternative 1SD** - No Action
- **Alternative 2SD** - Erosion Controls and New Benthic Layer, and Restore/Mitigate Disturbed Wetlands
- **Alternative 3SD** - Selective Excavation of Sediments, Place on Site, and Restore/Mitigate Disturbed Wetlands
- **Alternative 4SD** - Excavate Sediments, Place on Site, and Restore/Mitigate Disturbed Wetlands
- **Alternative 5SD** - Excavate Sediments, Dispose Off Site, and Restore/Mitigate Disturbed Wetlands

FOR DISCUSSION PURPOSES

Building Materials Alternatives

- **Alternative 1B** - No Action
- **Alternative 2B** - Demolish, Recycle Steel, Dispose of Other On Site
- **Alternative 3B** - Demolish, Recycle Steel, Dispose of Other Off Site
- **Alternative 4B** - Demolish, Recycle Steel, Dispose Other Partially On and Partially Off Site

FOR DISCUSSION PURPOSES

Soils Alternatives Screening

Alternative	Screening Summary
Alternative No. 1S – No Action	· Baseline
Alternative No. 2S – Capping and Institutional Controls	· Limited migration, Hg low mobility · Addresses direct contact – protective · Implementable
Alternative No. 3S – Selective Mercury Removal, Capping, Barrier Wall, and Institutional Controls	· Minimal impact on elemental Hg removal · Capping addresses direct contact – protective
Alternative No. 4S-1 – Partial Depth Selective Excavation and Disposal, Capping, and Institutional Controls	· Addresses direct contact plus partial subsurface removal– protective · Limited migration, Hg low mobility · Implementable
Alternative No. 4S-2 – Full Depth Selective Excavation and Disposal, Capping, and Institutional Controls	· Addresses direct contact plus subsurface removal– protective · Limited migration, Hg low mobility · Implementable

FOR DISCUSSION PURPOSES

Soils Alternatives Screening (continued)

Alternative	Screening Summary
Alternative No. 5S – Capping , Barrier Wall, and Institutional Controls	· Limited migration, Hg low mobility · Addresses direct contact – protective · Implementable
Alternative No. 6S – Treatment Cap, Barrier Wall, and Institutional Controls	· Limited migration, Hg low mobility · Addresses direct contact and vapor pathway – protective · Implementable
Alternative No. 7S – Selective Treatment by S/S, Capping, IC	· Potentially compromises stabilization · Not commercially available otherwise (e.g., BNL process)
Alternative No. 8S-1 – Selective Partial Depth Treatment by Stabilization, Capping and Institutional Controls	· Addresses direct contact plus partial subsurface treatment– protective · Limited migration, Hg low mobility · Implementable

FOR DISCUSSION PURPOSES

Soils Alternatives Screening (continued)

Alternative	Screening Summary
Alternative No. 8S-2 – Selective Full Depth Treatment by Stabilization, Capping and Institutional Controls	· Addresses direct contact plus subsurface treatment– protective · Limited migration, Hg low mobility · Implementable
Alternative No. 9S-1 – Selective Partial Depth Treatment by Soil Washing, Capping and Institutional Controls	· Addresses direct contact plus partial subsurface treatment– protective · Limited migration, Hg low mobility · Implementability problems with high fines, emissions · Fines disposal issues
Alternative No. 9S-2 – Selective Full Depth Treatment by Soil Washing, Capping and Institutional Controls	· Addresses direct contact plus subsurface treatment– protective · Limited migration, Hg low mobility · Implementability problems with high fines, emissions · Fines disposal issues
Alternative No. 10S – Complete Excavation and Off-Site Disposal	· Costly · Not appropriate for fill · Little additional advantage over other alternatives

FOR DISCUSSION PURPOSES

Groundwater Alternatives Screening

Alternative	Screening Summary
Alternative No. 1GW – No Action	· Baseline
Alternative No. 2GW – Capping and Barrier Wall, Shallow Groundwater Collection, Long-Term Monitoring of Deep Groundwater, and Institutional Controls	· Limited migration, Hg low mobility. · Cap will result in mound decline · Barrier further limits migration potential · Impacts to Deep GW not site related, monitor to confirm continued absence of site impacts · Implementable
Alternative No. 3GW – Shallow Groundwater Collection, Long-Term Monitoring of Deep Groundwater, and Institutional Controls	▪ Limited migration, Hg low mobility ▪ Collection further limits migration potential ▪ Implementable ▪ Impacts to Deep GW not site related, monitor to confirm continued absence of site impacts
Alternative No. 4GW – Monitored Natural Attenuation	· Source partially anthropogenic fill · Monitoring Impracticable in anthropogenic fill

FOR DISCUSSION PURPOSES

Sediments Alternatives Screening

Alternative	Screening Summary
Alternative No. 1SD – No Action	· Baseline
Alternative No. 2SD – Erosion Controls and New Benthic Layer, and Restore/Mitigate Disturbed Wetlands	· Bioturbation likely to recontaminate · Alter tidal exchange with fill
Alternative No. 3SD – Selective Excavation of Sediments, On-Site Disposal, and Restore/Mitigate Disturbed Wetlands	· Addresses ecological risk. · Implementable
Alternative No. 4SD – Excavate Sediments, On-Site Disposal, and Restore/Mitigate Disturbed Wetlands	· Addresses ecological risk · Implementable.
Alternative No. 5SD Excavate Sediments, Off-Site Disposal, and Restore/Mitigate Disturbed Wetlands	· Off-site disposal not more protective than on-site, but more costly

FOR DISCUSSION PURPOSES

Building Materials Alternatives Screening

Alternative	Screening Summary
Alternative No. 1B – No Action	· Baseline
Alternative No. 2B – Demolish, Recycle Steel, Dispose of Other Debris On-Site	· Addresses direct contact – protective. · Implementable.
Alternative No. 3B – Demolish, Recycle Steel, Dispose of Other Debris Off-Site	· Off-site disposal not more protective than on-site but more costly, particularly disposal of non-hazardous material
Alternative No. 4B – Demolish, Recycle Steel, Dispose of Other Debris Partially On-Site and Partially Off-Site	· Addresses building materials potentially containing free Hg · Non-hazardous debris remains on site.

FOR DISCUSSION PURPOSES

Combined Site Remedies

Combined Remedies
Remedy 1 – No Action
Remedy 2 – Cap, GW Collection, Partial SBC, Building Demo.
Remedy 3 – Cap, Barrier Wall, GW Collection, Partial SBC, Building Demo.
Remedy 4 – Treatment Cap, Barrier Wall, GW Collection, Partial SBC, Building Demo.
Remedy 5 – Cap, Barrier Wall, Stabilization, GW Collection, Partial SBC, Building Demo. (Partial Depth)
Remedy 6 – Cap, Barrier Wall, Stabilization, GW Collection, Partial SBC, Building Demo. (Full Depth)
Remedy 7 – Cap, Barrier Wall, Selective Excavation, Off-Site Disposal, GW Collection, Partial SBC, Building Demo. (Partial Depth)
Remedy 8 – Cap, Barrier Wall, Selective Excavation, Off-Site Disposal, GW Collection, Partial SBC, Building Demo. (Full Depth)

FOR DISCUSSION PURPOSES

Summary of Alternatives Screening

- Soils Alternatives Retained for Detailed Evaluation
  - Containment
  - Stabilization
  - Selective Excavation and Disposal

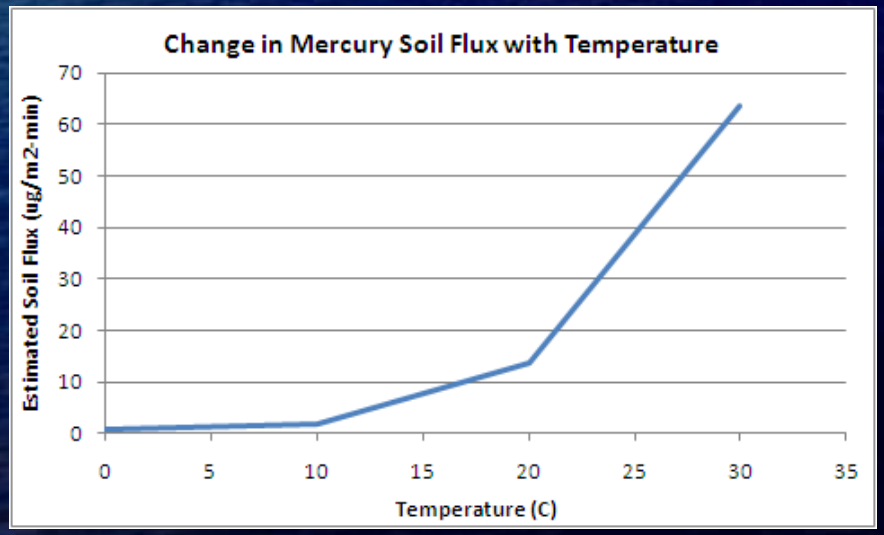
FOR DISCUSSION PURPOSES

Key Considerations for Retained Alternatives

- Mercury vapor emissions/flux
  - Excavation
  - Treatment
- Reagent type and quantity – stabilization
- Stabilization treatment efficiency
- LDRs and Alternative Treatment Standard
- Treatment cap efficiency
- Off-site disposal
  - USEcology/Stablex
  - Mercury export ban

Mercury Emissions/Flux

- Empirical data
  - 0-3 ug/m^2-min, Hg up to ~150 ppm
  - 0-168 ug/m^2-min, Hg up to ~3,000 ppm (Orica site – chlor alkali facility)
- Temperature effect (consistent with Ventron/Velsicol)



- Average from Orica data : 47 ug/m^2-min

Mercury Emissions/Flux

Ventron/Velsicol Air Monitoring

- 1,000 to 10,000 ppm
- Visible Hg – limited areas
- 20-30 ug/m^3 peak during excavation
- 0.3 ug/m^3 annual avg. chronic reference conc.
- OSHA PEL (0.1 mg/m^3) – stop work
- HgX used as control measure
- 70^0 F breakpoint temperature

Mercury Emissions/Flux

Ventron/Velsicol Air Monitoring from Suppression Testing

- Three 25 ft^2 test areas
  - Mean: 1.2 – 66.5 ug/m^3
- One 400 ft^2 test area
  - Mean: 21ug/m^3

Mercury Emissions/Flux

Ventron/Velsicol Air Monitoring

- Calculated Flux, excavation, 0.25-0.5 ac @
  - 0.3 ug/m^3
  - 25 ug/m^3
- Calculated Flux, 400 ft^2 test plot
  - 21 ug/m^3
- Results:
  - @ 0.3 -- ~2 ug/m^2-min
  - @ 20-30 -- ~150 ug/m^2-min
  - @ 21 -- ~ 151 ug/m^2-min

$$C_o = \frac{J_S}{Q/C \bullet 10^{-9}}$$

Where:

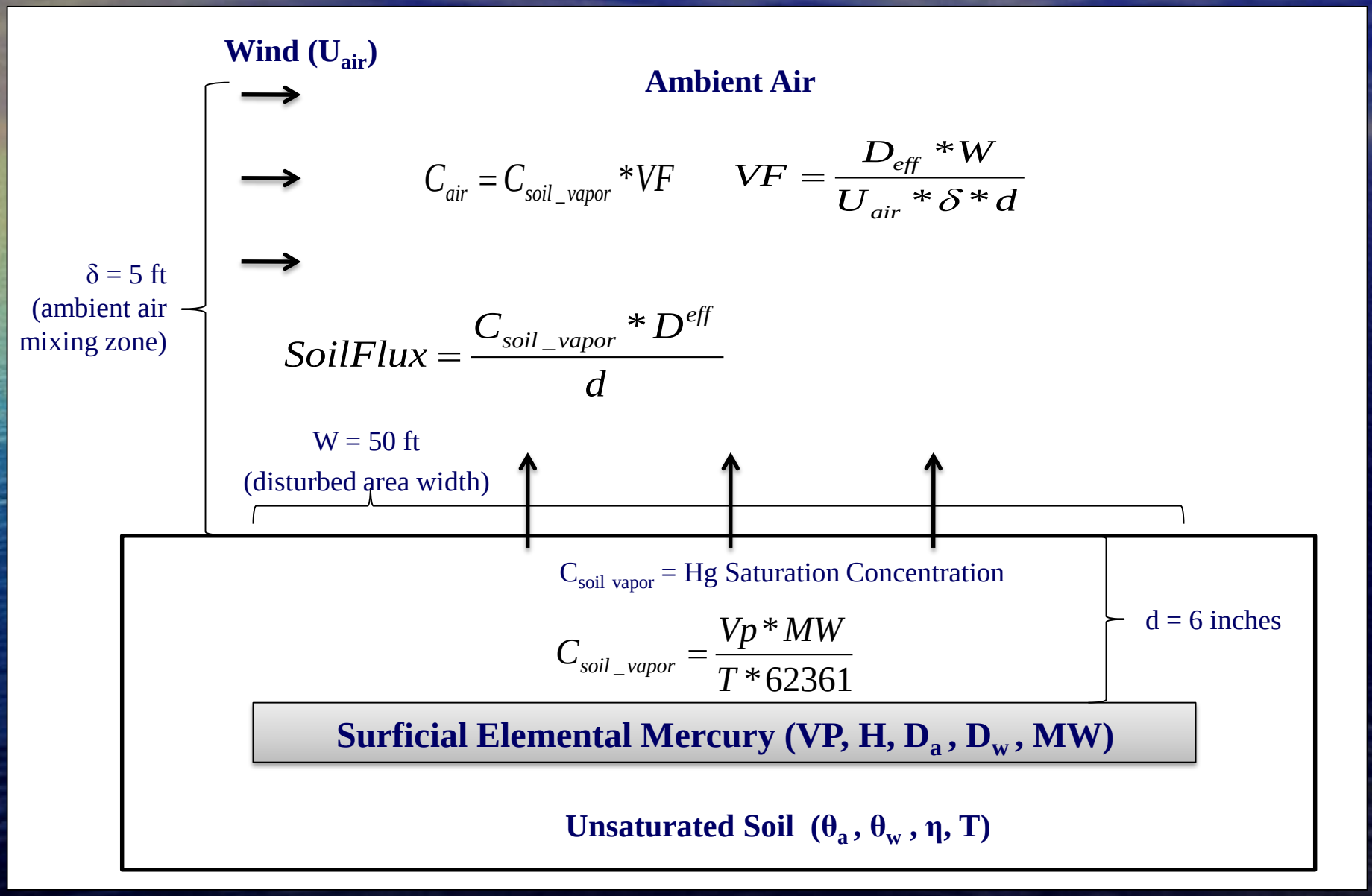
C_o = Outdoor air concentration ($\mu g/m^3$)

J_S = Contaminant flux from the surface of the ground (measured) ($g/s/m^2$)

Q/C = Dispersion term calculated for area ($g/s/m^2$ per kg/m^3)

10^{-9} = Units conversion to from kg/m^3 to $\mu g/m^3$

Hg^0 Diffusion Calculation



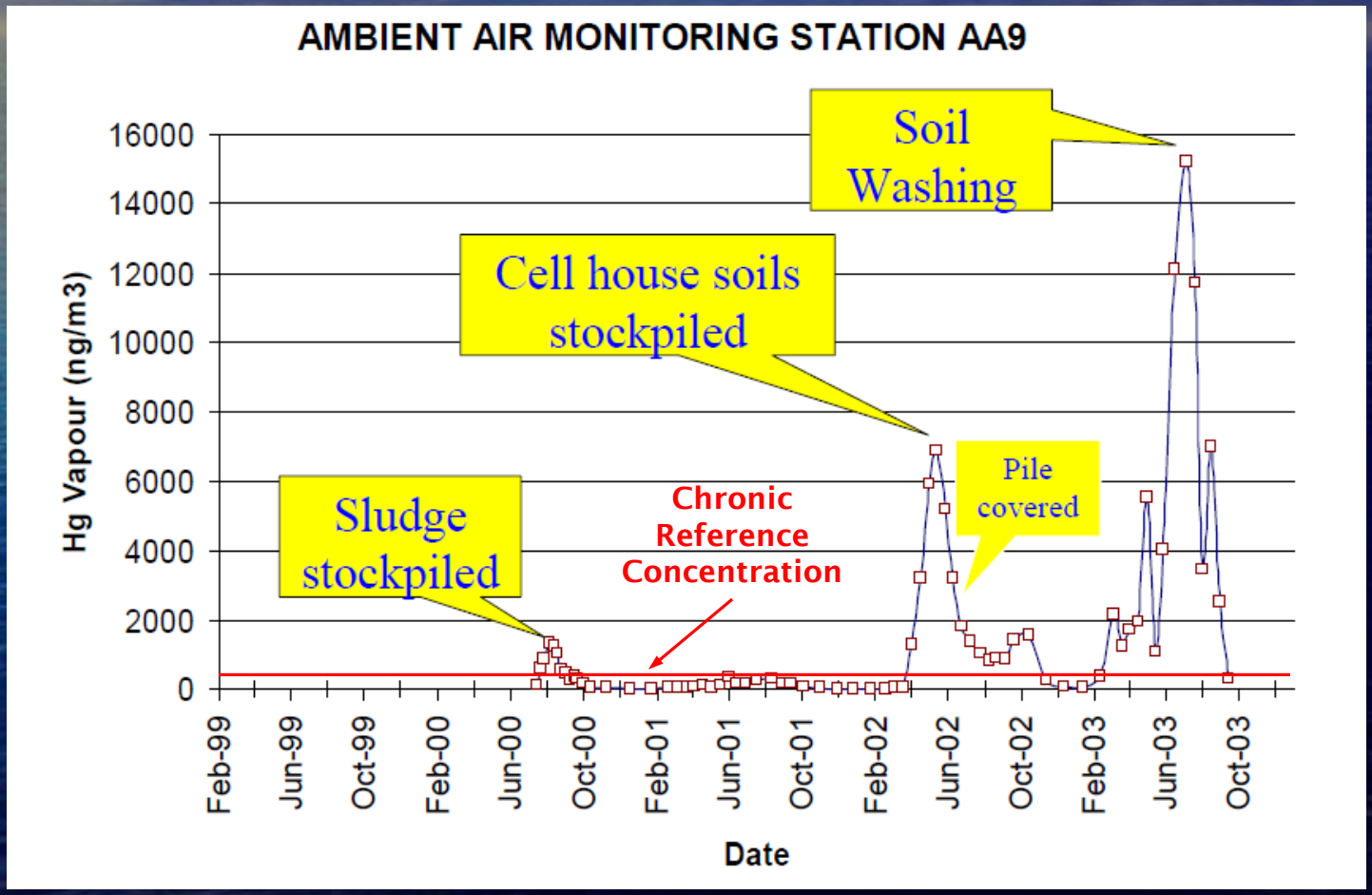
Mercury Emissions/Flux

- Calculated flux from soils,
  - Variable temperature,
  - 2,100 mg/kg Hg (C_{sat_soil} = 46 mg/kg)
  - 90,000 SF area of visible Hg

Temperature, °C	Flux, ug/m²-min
0	0.037
10	2
20	14
30	64

Remedy Mercury Emissions

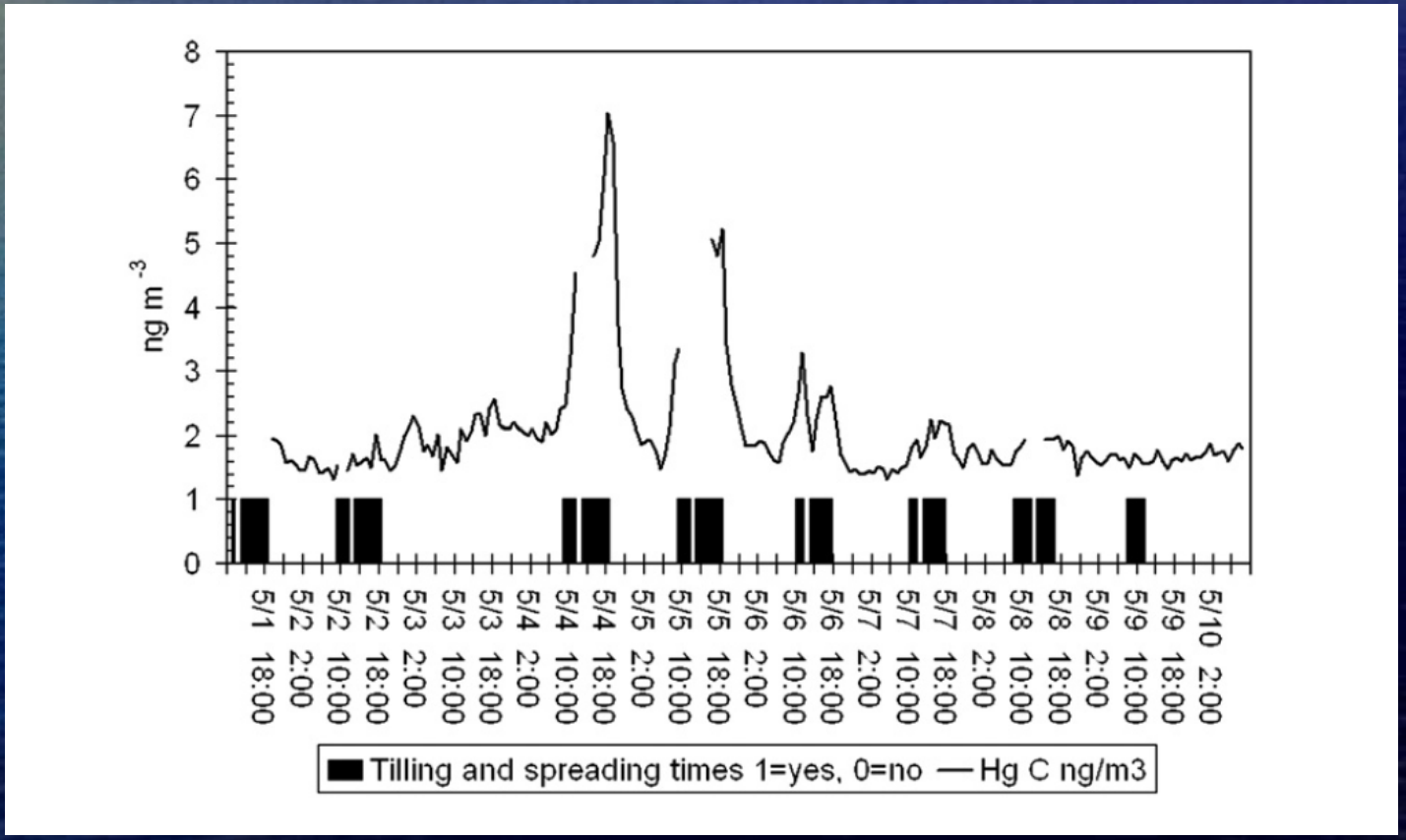
Squamish Chlor-Alkali Site Remediation Air Monitoring



Turner, R., "Nature and Effectiveness of Remediation at a Hg-Contaminated Site", 2009

Remedy Mercury Emissions

Downwind Mercury Concentrations During Agricultural Field Preparation



J.O. Bash, D.R. Miller / Science of the Total Environment 388 (2007)

FOR DISCUSSION PURPOSES

Remedy Mercury Emissions

- Baseline adjustment factors:
  - Earthmoving activities: 4-6x
  - Stockpiled soil: 2x
  - S/S: 2x
  - Soil Washing: 10x

FOR DISCUSSION PURPOSES

Treatment Cap Conversion Efficiency

- Adjusted diffusion calculation parameters:
  - Depth – 6”
  - Temperature – 13° C
  - Assuming C_{sat} maintained
    - 3.3 ug/m^2-min treatment
    - 0.02 tons/yr conversion of Hg^0 to HgS

Stabilization

- Various reagents
  - Cement
  - Sulfur
  - Proprietary mixtures
- Mixed results
- Sulfur – HgS (lowest solubility)

Stabilization Waste Loading

- Typical – 30% - 70% waste loading
- No testing where Hg^0 observed
- LCP Bridge Street: 2.2 lbs Hg^0/CY soil
- Sulfur quantity for stabilization:
  - Stoichiometric ~ 0.5 lb S/lb Hg (~0.02% soil wt)
  - Stoichiometry does not control
  - Use range 50-95% waste loading

Stabilization Conversion Efficiency

- Conversion Efficiency (empirical data):
  - 50% (Hg^0 + S^0 in pugmill)
  - 90%+ (Pugmill , sand added)
  - 20 – 80 % (Hg^0 + S^0 well mixed vial, alkaline increased)
  - 85% (BNL process, minimum conversion)
  - 99+% (BNL heat and time)
  - ~99% (Hg^0 + S^0, milling for 90 minutes)
- FS conversion efficiency based on above and fill
- FS conversion efficiency to be verified with pre-design treatability study

LDRs/ATS

- D009 – 0.2 mg/L TCLP
  - > 260 mg/kg – Retort
  - < 260 mg/kg retort residue – 0.20 mg/l TCLP
  - < 260 mg/kg non-residue – 0.025 mg/l TCLP

- Alternative Treatment Standard
  - 10X UTS
  - UTS = 0.025 mg/L TCLP
  - ATS = 0.25 mg/L TCLP
  - Use 0.2 mg/L hazardous waste definition

Soil Washing Empirical Data

- Feed – LCP Bridge Street
  - 30 feed samples, 5 at 0.219 – 0.648 mg/l
  - Feed samples all > 260 mg/kg
- Fines – LCP Bridge Street
  - 34 batches
  - Total Hg: 689 – 8,780 mg/kg
  - 26 TCLP results 0.24 – 11.9 mg/l
  - After stabilization 9 of 10 samples 0.032 – 0.354 mg/l
  - ~5% stabilized material > 0.2 mg/L disposed off site
  - 0.354 mg/L TCLP, 1,770 mg/kg total

FOR DISCUSSION PURPOSES

Off-Site Disposal, USEcology/Stablex Canada

- Can accept waste with free elemental Hg
- Additional H&S in treatment building
- Stabilization process – proprietary
- Performed in bins
- Stabilized waste landfilled
- If residual Hg in bins – retort
- Might consider process modification

Hg Export Ban

- Not subject to MEBA
  - "Media … and debris that are managed for implementing cleanup"
  - "Industrial, commercial and remediation residuals"
- If component of remediation is recovery for resale or reuse, subject to MEBA
- Hg from bin residual retort, if any, would have to be returned